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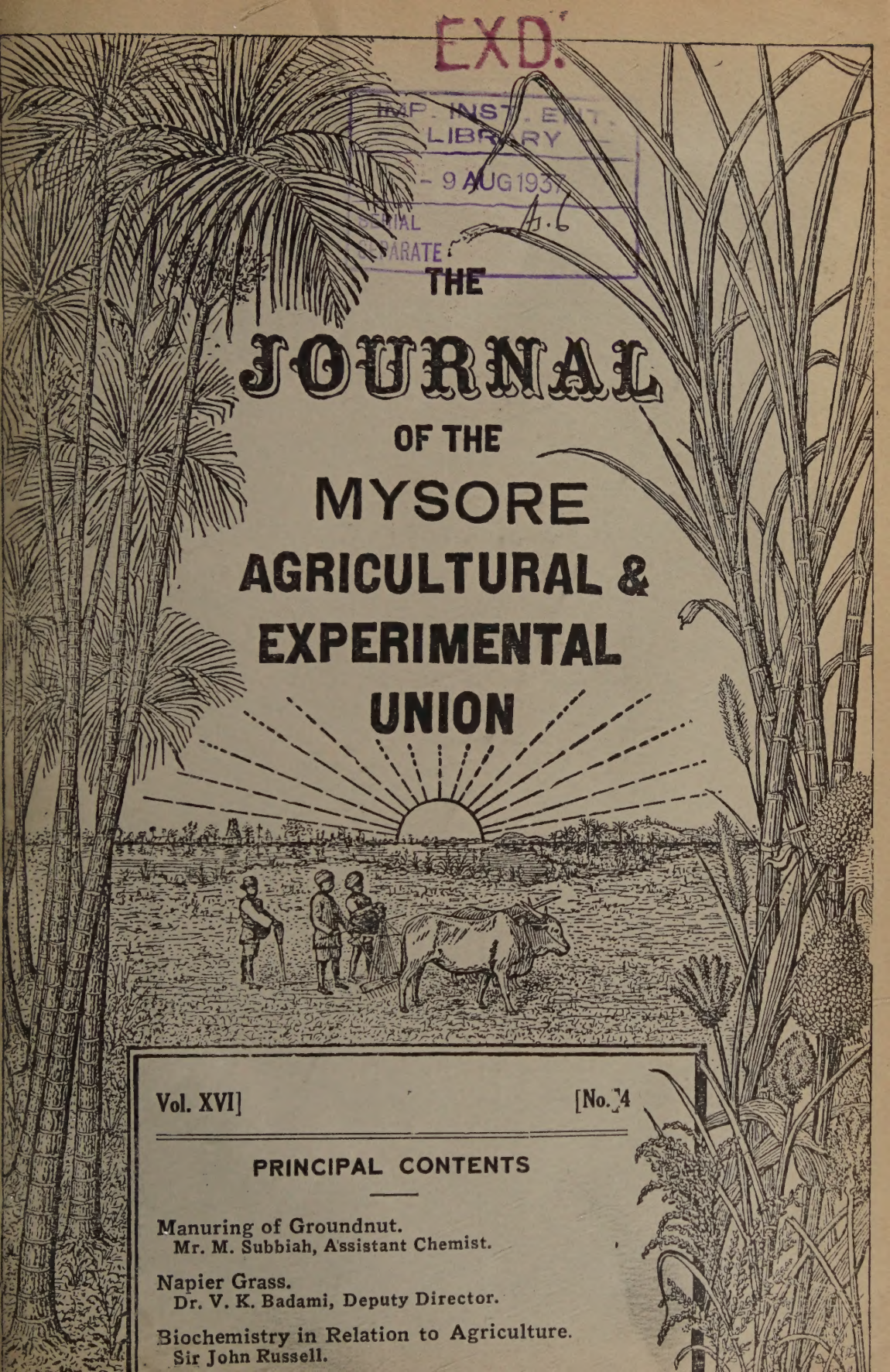

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Vol. XVI] [No. 4

A Short Note on Groundnut Manurial Experiments on the Irwin Canal Farm, Mandya

By

M. Subbiah, B.A., *Assistant Chemist*

Introduction

The policy of irrigation now in vogue in the Irwin Canal tract precludes growing paddy or sugarcane year after year on the same piece of land. A three-year rotation is insisted upon; in this course, dry crops, requiring intermittent supply of irrigation water appear once in three years. With the object of devising proper kinds of rotation, experiments with various crops have been conducted on the Irwin Canal Farm, the very establishing of which is, to quote Dr. B. Narasimha Iyengar, Director of Agriculture, "to study the problems peculiar to the tract, devise proper kinds of rotation, find out suitable varieties of crops". On account of its economic importance and also on account of its indirect beneficial influence on the succeeding crops, groundnut is given a prominent place in the list of dry crops. To test if groundnut cultivation in this tract could be a profitable concern, the manurial requirements of this crop were studied on the soil of the Irwin Canal Farm, which may be taken as representative of this tract.

It has been stated above that groundnut exerts an indirect beneficial influence on the succeeding crops. It would be instructive to illustrate this point by the rotational experiments carried out by D. N. Mehta and D. L. Janoria[1] in the Central Provinces. Cotton and jola, being the main kharif crops in this tract, the choice of rotation was restricted to these two crops by the ryots. As a result of this practice, the yield of cotton and jola diminished considerably in many places. Investigations to find out the causes of low yields were begun on the Government Experimental Farm, Akola, and as a result of these investigations, it was shown that by including groundnut in the scheme of rotation, the cotton crop could be increased by 130 per cent. over the cotton crop grown year after year. The rotation of cotton-juar-groundnut, found suitable as a result of investigations, for the black cotton soils of Berar, has been shown to yield a gross profit of Rs. 83–2–0 against a profit of Rs. 7–9–0 realised by growing cotton after cotton. It is thus evident that the problem of low yield of cotton in the Central Provinces has been solved by merely including a leguminous crop like groundnut in the scheme of rotation.

Manurial Experiments Carried out at Other Centres

The manurial requirements of groundnut have been tested at various places in India and the results of field experiments have been statistically examined by the Statistician to the Imperial Council of Agricultural Research. A brief summary of these experiments is given below; for greater details the original Report[2] may be consulted.

Experiments carried out on *black cotton soils* such as occur in the Bombay Presidency and in the Central Provinces indicate that nitrogenous single manures do not produce any significant effect on yield.

---

[1] *Ind. Jour. Agric. Sci.* 1933, Vol. 3, p. 917.

[2] "Analysis of Manurial Experiments in India," *I.C.A.R.*, 1934, Vol. I, p. 17.

On the Poona Agricultural College Farm compound manuring such as the one given below seems to have produced a significant increase in yield (50 per cent.) over no-manure.

Farmyard manure 5 carts + super 640 lbs. + sulphate of potash 320 lbs. + sulphate of ammonia 128 lbs. per acre.

At Akola, Central Provinces, simple manuring with basic slag at 640 lbs. per acre and bone-meal at 240 lbs. per acre was found to be effective. Sulphate of potash at 240 lbs. per acre gave 20 per cent. significant increase over no-manure.

Experiments carried out in Burma *on light sandy loam,* alkaline and poor in all essential elements of plant food, indicate that nitrogenous manures used alone would give significant increase in yield over no-manure. The proprietary manure such as nicifos at 30 lbs. N per acre either alone or in combination with sulphate of potash at 60 lbs. K_2O per acre has also given significant increase in yield.

Experiments carried out for four years on the Hebbal Farm, Mysore, *on red sandy loam* fairly rich in potash but poor in nitrogen, phosphoric acid and lime, have indicated that in the limed series, treatment with superphosphate would give the same yield as the treatment with complete manure, supplying nitrogen, phosphoric acid and potash (23 per cent. increase over unlimed check). The addition of potash to super has decreased the yield by 6 per cent. There is also a slight response to liming (9 per cent. increase over unlimed plot).

The above experiments, though too few to warrant drawing definite conclusions, serve to show the following indications. As was to be expected with a leguminous crop, groundnut responds to phosphates. Its response to nitrogenous fertilizers is of a doubtful nature. It has responded to nitrogen on the sandy loams in Burma. These soils are alkaline and low in organic matter. Hence nitrogen fixation due to bacterial activity should also be at a low level. Under these circumstances it is but natural to expect that

nitrogenous manures have exerted a beneficial influence on groundnut. The response to potash manuring has also been noted at Akola.

Experiments on the Irwin Canal Farm, Mandya

The distinctive feature of the experiments carried out on the Irwin Canal Farm, Mandya, is that the lay-out followed is one of random block and so the conclusions arrived at as a result of statistical examination of the results of the experiment may be taken to be reliable. Experimental plots were laid out on soil which had come under paddy only once, prior to which it had not known cultivation of any kind within living memory. The manurial scheme and the lay-out were prepared by Dr. B. Narasimha Iyengar and the experiments were conducted by Mr. C. V. Ramiah, Superintendent of the Farm. The land selected for the experiment is of a sandy and gravelly soil. The variety of groundnut used for the experiment was H.G. 1 evolved by the present Deputy Director and Economic Botanist of the Department, Dr. V. K. Badami. Manures were applied to the soil before sowing and well worked into it. The seeds were soaked in water overnight and were sown in the morning of 29th July 1933 using a seed drill; and the crop was harvested on 9th December of the same year. The experiment was laid out in four blocks consisting of five treatments distributed at random in each block. The treatments were as follows: (numerals refer to dosage for one acre).

1. Control.
2. 80 lbs. of concentrated super + 75 lbs. of ammonium sulphate.
3. 80 lbs. concentrated super + 90 lbs. muriate of potash.
4. 80 lbs. concentrated super + 75 lbs. sulphate of ammonia + 90 lbs. muriate of potash.
5. 80 lbs. concentrated super + 75 lbs. sulphate of ammonia + 180 lbs. muriate of potash.

The effects of (*a*) ammoniacal nitrogen, (*b*) potash, (*c*) the addition of potash to phosphoric acid, (*d*) the addition of a double dose of potash to nitrogen and phosphoric acid on yield of groundnut were some of the points which were studied. The results obtained are given in Table I and statistically examined in Tables II, III and IV.

TABLE I.

Yield data — Yield of dried pods in lb. per plot of 1/40 acre

Block A	Block B	Block C	Block D
(5)	(2)	(3)	(4)
17·87	20·3	16·65	18·68
(4)	(1)	(2)	(3)
21·12	15·02	19·49	25·79
(3)	(5)	(1)	(2)
27·62	25·99	8·93	20·3
(2)	(4)	(5)	(1)
21·97	29·24	24·37	15·02
(1)	(3)	(4)	(5)
17·46	32·9	29·65	26·8

TABLE II

(*Analysis of variance*)

Due to	Degrees of freedom	Sum of squares	Mean square	Z
Blocks ..	3	57·4	19·13	
Treatments ..	4	359·3	89·82	0·6084
Error ..	12	265·5	22·13	

The value of 'Z' when $n_1 = 4$ and $n_2 = 12$ for five per cent. level is 0.5131 (P. C. Mahalanobis, *Ind. Jour. Agr. Sci.*, Vol. 11, Part VI, December 1933, page 679).

As the observed difference of 0.6084 is more than the difference 0.5131 required for 5 per cent. level, the treatment seems to be significant.

TABLE III

Mean yields per acre

Treatments	1	2	3	4	5	Mean	Standard error	significant difference
Pods per acre ..	566	820	1070	987	951	870	94·9	290·4
Per cent. ..	64·8	94·2	118·4	113·4	109·3	100	10·9	33·4

Significant difference = 290.4 lbs. per acre.

Any increase in yield greater than 290.4 lbs. per acre will certainly be due to manures.

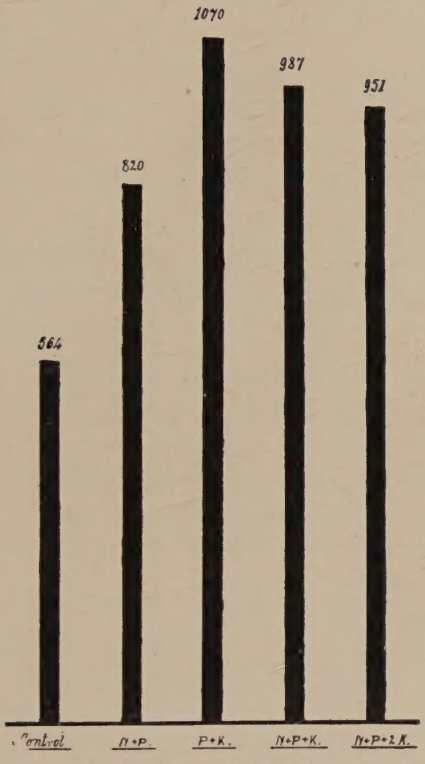
TABLE IV

Manurial treatment	Mean yield per acre (lb.)	over treatment 1	over treatment 2	over treatment 3	over treatment 4
1. Control	(564)				
2. 80 lbs. super + 75 lbs. A/S (N + P)	820	256			
3. 80 lbs. super + 90 lbs. KCl (P + K)	1070	506*	250		
4. 80 lbs. super+75 lbs. A/S+90 lbs. KCl (N + P + K)	987	423*	167	83	
5. 80 lbs. super+75 lbs. A/S + 180 lbs. KCl (N + P + 2 K)	951	387*	131	119	36

* Increase in yield highly significant.

From the information now available the following conclusions may be drawn:—

By comparing treatments (1) and (2) it is seen that ammonium sulphate has not given significant increase in yield over control. The addition of nitrogen to (P + K) treatment as in (4) has not resulted in any increase in yield over treatment (3). It is therefore evident that groundnut



Graph indicating yields of Groundnut under different treatments.

has not responded to the application of nitrogen as ammonium sulphate in this soil.

The addition of potash to phosphoric acid has increased the yield significantly. By doubling the dose of potash as in treatment (5) the yield has not increased over the single dose.

General.—The best manure to apply to a soil of this type appears to be a mixture containing both phosphoric acid and potash. Nitrogen has produced no great increase in yield. The conclusions that groundnut responds to phosphoric acid and potash and that its response to nitrogenous fertilizers is of a doubtful nature, may also be supported by experiments reported from other centres and described previously in this paper.

The yields under different treatments are represented graphically in the accompanying illustration.

TABLE V

Financial Aspect

Treatment	Yield of pods per acre	Value	Cost of manure	Net profit due to manure alone	Remarks
	lbs.	Rs. A. P.	Rs. A. P.	Rs. A. P.	
Control ..	564	27 11 0	..	..	
N + P ..	820	40 4 0	8 11 0	3 14 0	
P + K ..	1070	52 8 0	12 0 0	12 13 0	
N + P + K ..	987	48 7 0	16 2 0	4 10 0	
N + P + 2K ..	951	46 11 0	23 9 0	4 9 0	loss

* Groundnut Rs. 1-6-0 to 1-7-0 per maund of 28 lbs.

Column (2) of the above table shows the money value of groundnut harvested under each treatment. Column (5) gives the net profit or loss over control due to each treatment. Even from the point of money return, the treatment (P + K) seems to give better paying responses than other treatments.

Napier Grass

By

Dr. V. K. Badami, L.Ag., Ph.D.

Deputy Director of Agriculture

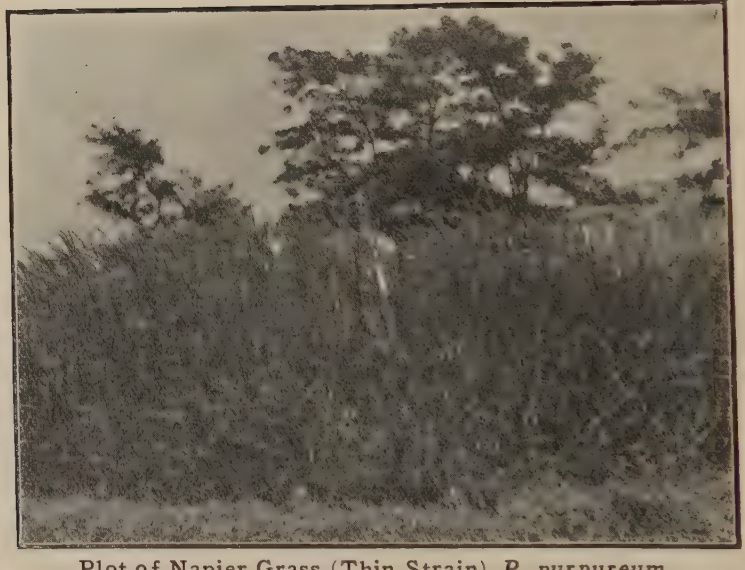
Napier Grass often known as Elephant Grass is a native of West Africa. It was introduced into the United States of America several years ago and has become fairly common in the Southern States bordering the Gulf of Mexico, specially in the sea-girt peninsula of Florida. Napier Grass is said to flourish there and furnish abundant grazing if grazed cautiously. Continuously grazed plots have been killed in six months whereas the intermittently grazed ones stood up well. Apparently it pays to keep Napier Grass well cultivated while being grazed and it has been found there that the cultivated plots are better than the uncultivated ones. It is a coarse grass with stiff stalks. When fully ripe only the leaves are fit for feeding live-stock. In the earlier stages of growth when the stalks are still tender, the grass is cut and made into silage. It seems to stand draught and heavy amount of moisture in the soil but not water-logging. Under controlled irrigation and sewage, heavy yields can be cut even on poor sandy soils. As far as the nutritional value is concerned it seems to be a moderate one and cannot compete with the more nutritious and palatable fodders like maize, jola, sun-flower, Johnson Grass or teosinte.

Napier Grass or Elephant Grass (*Pennisetum purpureum*), has many closely allied species of grasses in India alone. The cultivated crop of cambu or sajje is one (*Pennisetum typhoideum*) and Kolakatte Grass of the Coimbatore District is another (*Pennisetum anchroides*). Kolakatte Grass is grown over several thousand acres by the famous cattle breeders of Kangayam near Erode. Several years ago when Mr. C. Venkata Rao was the Superintendent of the Amrithmahal Department, he introduced and tested the Elephant Grass in the *kavals* in many places but it could not compete and establish itself against the local Marvally and *Lekanikakaddi*. The Department of Agriculture in

Harvesting Napier Grass.

Cattle relish Napier Grass.

Indigenous Grasses.



Plot of Napier Grass (Thin Strain) *P. purpureum.*

Bengal is now trying to popularise this grass in the rural parts; probably it is well suited to the water-logged alluvial areas of Bengal.

The Department of Agriculture in Mysore introduced the Napier Grass (Elephant Grass) from the United States of America about twenty years ago and it is under observation since then. On the Hebbal Farm it has been treated as a dry land grass. It is perennial and a cutting is taken once a year. The lines in the cultural plots planted twenty years ago are still yielding heavy yields without much attention. When it grows old the canes or stalks become very hard and dry for cattle feeding. Only the leaves can be used. Our cattle used to more palatable grasses and fodder like maize stalks and jola stalks do not relish this grass.

Recent tests show that the sap of Elephant Grass is not so good as those of others.

	Brix.
Sap of Elephant grass young stalks ..	5·0%
„ Jola stalks (Kaki jola)	10·5%
„ Maize stalks	11·5%

From the information available from the various publications of the scientific stations of the U.S.A., Napier Grass (Elephant Grass) does not seem to be so nutritious as other grasses which are under observation on the Hebbal Farm.

	Per cent. of					
	Water	Protein	Fat	Nitrogen free extract	Fibre	Ash
Green Maize ..	79·8	2·00	0·70	12·1	4·3	1·10
Sorghum ..	79·4	1·30	0·60	11·6	6·1	1·10
Teosinte ..	79·8	0·90	0·30	11·5	6·2	1·30
Johnson Grass	81·6	0·90	0·16	8·7	3·5	0·76
Napier Grass (Elephant Grass)	80·0	0·34	0·15	2·3	1·5	0·43

Under irrigation and cultivation this grass (Elephant Grass type) does not seem to give better yields or better

quality of fodder than the others under test. Extensive feeding experiments conducted on the Experiment Station in Florida in 1925, indicate that maize is a better fodder for milch cows than Elephant Grass.

Along with a number of other grasses another type of Napier Grass (*Pennisetum purpureum*) has been introduced by us from the Department of Agriculture, U.S.A., about 15 years ago. This belongs to the same species of Napier Grass (Elephant Grass) but has thin palatable stalk. This grass tillers freely and thrives on even poor dry soils. The propagation is easily made by planting suckers just after a heavy rain in May or in August. The general growth is usually over 4 ft. in height and two cuttings may be taken during the year. It can be used only as green fodder or can be easily converted into silage. At present this type of Napier Grass is being tested and multiplied on other Government Farms.

Its hardiness and luxuriant growth gave great hopes at one time and attempts were made to establish it as a natural grass in gomal lands and forest areas. But it is now found that without care and attention Napier Grass cannot compete with the local coarse flora. The coarse *hanche hullu, Gayalgarike* and other allied grasses grow quickly and smother the Napier Grass in 4 or 5 years. In case the plots are given a cultivation and a slight manuring, heavy crops can be grown in the State with this finer type of Napier Grass.

The photographs show the method of planting the finer type of Napier Grass, its growth in the dry plots, its growth in a pasture and the manner in which the cattle relish it.

Testing of various imported and indigenous grasses is one of the items of work attended to by the staff of the Botanical Section. More intensive work has to be done in testing their agricultural qualities and nutritive values. These problems can be taken up as funds and facilities are made available.

Sir J. Russell's Visit to India

Agricultural Expert—Pioneer Work in England

Sir John Russell, who arrived in India on November 4, 1936, as one of the two experts to advise on the work of the Imperial Council of Agricultural Research, is the Head of the Rothamsted Experiment Station in England.

The Rothamsted agricultural experiments are the oldest in the world, and were started in 1843 by John Bennet Lawes, an English squire, at the Manor House of Rothamsted in Hertfordshire. Lawes' first big achievement was the discovery of artificial fertilizers and the consequent establishment of an industry that now produces about 40 million tons of fertilizers every year. Lawes soon associated with himself a chemist, Joseph Henry Gilbert, and their collaboration lasted for 60 years. It was an ideal partnership.

For the first 12 years the laboratory in which Lawes and Gilbert worked was a barn. In this they made their first superphosphate and tried it out on the field which lay just outside.

Report after 20 Years

Lawes and Gilbert continued their experiments with superphosphate, sulphate of ammonia and sulphate of potash, comparing their effects on crops with that of farmyard manure. They were not in a hurry to publish their results (a lesson for moderns) and it was 20 years before they wrote up a full account of their experiments. Twenty years later they wrote another description and at the end of 50 years Gilbert wrote an account of the whole of their results.

Their successors have been Sir Daniel Hall from 1902 to 1912 and Sir John Russell, who is the present Director. Throughout the whole period certain experiments have continued in an unbroken sequence, so that on the same plots as at the outset, there are being grown the 53rd crop of

mangolds, the 78th crop of hay, the 80th crop of barley and the 92nd crop of wheat.

Work at Rothamsted has branched out in all directions. It now deals with cultivation, that is the study of tilth. It deals with crop diseases, insect-pests, livestock, agricultural engineering and many other subjects. It has been particularly successful in its study of the bacteria affecting agriculture both in the soil and in the plant.

These brief details are culled from *The Story of the Rothamsted Experimental Station*, published by that Station, giving a brief and sketchy idea of the institution of which Sir John Russell is now the head.

Essence of Research

It is on research that all progress is founded. The essence of research is to get at the causes of things, whether good or bad and, having found the causes, to apply that knowledge for the use of mankind. When we have got the facts, we have to use them.

The following remark from a leader in the scientific journal *Nature* some five years ago, bears on this point:—

"If the future of society largely depends on our ability to link administrative power with the knowledge of the scientific factors involved in our modern problems, that combination can only be secured when the scientific worker adds to his knowledge the wisdom which is the fruit of a balanced development."

Varied Experience

Sir John Russell admirably fulfils these requirements, and it is certain that agriculture throughout India in all its aspects, will benefit by his scientific scholarship, his ripe and varied experience and the fact that he will be able to see, as a whole, the varied and far-flung researches now financed entirely or in part by the Imperial Council of Agricultural Research.

This field will certainly be fertilized by his fresh and vigorous thought. The task that he has undertaken is a very big one. The actual physical distances to be covered are great and the experimental stations to be visited are many. In addition, Sir John will also see all variations of local agriculture, improved and unimproved, and will also get an idea of the extent to which propaganda by the agricultural departments and others has been able to "put across" the results of research.

India welcomes this visit of a real scientific *guru*, many of whose disciples are to be found throughout the length and breadth of India and whose personal knowledge of research, administration and propaganda will help on the amelioration of the country's greatest and most important occupation.

"Times of India," Bombay.

Need of Scientific Farming in India

Sir J. Russell's Plea

"The strength of India lies in its villages and not in the towns, and the greatest problem before the agriculturists in this country is how to improve the condition of the peasants living in these villages," said Sir John Russell, the agricultural expert who is on a visit to Poona, in a lecture at the Agricultural College this morning.

Mr. W. J. Jenkins, Director of Agriculture, introduced the lecturer who, he said, was Director of the Rothamsted Agriculture Experimental Station and had been invited by the Government of India to study agricultural problems in India. Among those present were Lady Russell, Principal V. G. Gokhale, Mr. B. S. Kamat, M.L.C., Prof. V. G. Kale and a large number of students and professors of the College.

Sir John described the condition of agriculture in the old days when, even in countries other than India, machinery

and implements were not much used. The problem in those days, he said, was to increase the produce and reduce the cost of production. Improvement in the machinery and implements used on the farms had to be made in order to cope with the necessity of reducing the cost of production. The cost of production of wheat in Canada was extremely low owing to the use of improved machinery and implements. The agriculturist had now become an engineer. Fifty years ago bullocks and horses were used even in England, but now the modern tractor improvements had been introduced in their place.

Conditions in India

Referring to India, the lecturer said that agriculture in this country was also entering a very important and critical period. There were crops in India which had a world market. These were not able to compete with other countries because of the high cost of production in India. India must use new and improved methods and varieties of crops and seeds; it must stop diseases, increase the yield, use manures, and reduce costs. Then only would the country be able to stand in the drastic competition of the world market.

Other crops produced for consumption in India had also to be improved. The greatest task before the agriculturist in the country, however, was to improve the condition of the peasant, who was not well off and was unable to buy the ordinary amenities and comforts of life. It was the duty of those in the towns to provide the needs of the peasant.

The problem, however, was not peculiar to India alone, continued Sir John. All over the world young men and women from the villages were anxious to obtain a higher standard of life and were going to the towns to find this. He instanced Poland, which was in many ways similar to India and had the same problems. The co-operative movement, village uplift and other efforts were being made there as in India.

SIR JOHN RUSSELL AT THE DEPARTMENTAL LABORATORIES.

Sir John Russell and his Secretary.

At the Pot-culture House.

At the Plant Breeding Cage.

At the Bee House.

Amrit Mahal Cattle.

Sir John Russell on the Irwin Canal Farm.

Dr. and Mrs. Wright on the Sheep Farm.

Concluding, the speaker said that the purpose of scientific agriculture was to attain the necessary high standard of life in the villages. Science had done great things in the past and was capable of doing much more in the future. Indian agricultural scientists had to solve this problem.

"Times of India," Bombay.
December 1936.

Dairy Expert in Bangalore

Visit to the Imperial Animal Husbandry Institute

Dr. N. C. Wright and Mrs. Wright, accompanied by Capt. Aggarwala, Secretary and Adviser, arrived here last night and are staying as State guests at 'Kumara Park'.

Dr. Wright and Capt. Aggarwala visited the Imperial Dairy Institute to-day and spent the whole day there. Mr. Zal R. Kothawala, Imperial Dairy Expert, showed the visitors round the several departments. Dr. Wright inspected the livestock and was particularly impressed with the methods adopted in breeding pure Gir and red Sindhi stock. Dr. Wright was shown several departments at work, including the instructional classes. He was shown the various hygienic methods adopted in handling milk and milk products. He was shown students at work, grooming and milking the cows, cleaning the sheds and making cheese.

At the laboratory Dr. Wright was shown the several lines of research being pursued now, such as the manufacture and standardisation of "Surti cheese". This is specially intended for small holders and to be worked as a cottage industry without the aid of elaborate machinery. More profitable methods of ghee boiling, including a specially designed boiler in which the nutritive contents are preserved in the process of boiling, and chemical and bacteriological researches on milk and liquid and solid milk products were demonstrated. Most of the researches are pursued with the general object of making scientific dairying

profitable to the villager. Dr. Wright seemed much impressed with the work of the Institute.

Food and Milk

The Dairy Expert was shown also the nutrition section, where under its expert, Mr. Cox, experiments are being carried on for deciding the best quantity and quality of food for cows while milking and while dry as well as for determining how different foods affected the vitamin and other contents of milk.

In the afternoon, Dr. Wright discussed with Mr. Kothawala future plans for the development of the Institute. In the evening, he visited with Mr. Kothawala the Bomanpally Dry Stock Farm, where young stock and dry stock are brought up.

"Times of India," Bombay.
December 1936.

Biochemistry in Relation to Agriculture

Indian Ryot Consumes One Pound of Grain per Day

"Biochemistry in relation to agriculture" was the theme of an interesting lecture delivered by Sir John Russell, Director of the Rothamsted Experimental Station, at the Indian Institute of Science under the auspices of the Society of Biological Chemists (India), when Sir C. Venkata Raman, Director of the Institute, presided. A large gathering of students attended the meeting.

Prior to the meeting, Sir John and Lady Russell were entertained at tea by the Society of Biological Chemists.

Sir Raman Introduces Sir John Russell

Sir C. V. Raman, in the course of his introductory remarks, gave a short sketch of Sir John's career and the work he was doing at the Rothamsted Experimental Station. He humorously remarked that it was not often that the Government of India did the right thing, but on the present

occasion, however, they had by some strange lapse chosen the right man to go over to India and put Agriculture in this country on its feet (laughter). Sir John was a man of profound knowledge in the problems of agriculture. With a life-time of knowledge, experience and sympathy Sir John would prove most valuable in solving the Indian agricultural problem which is engaging the attention of the Government at the present time.

Dr. Gilbert Fowler, speaking next, associated himself with the sentiments expressed by Sir Raman and expressed his great debt to Sir John, who had always extended very cordial help to him (Dr. Gilbert Fowler) in his scientific work.

Sir John Russell's Lecture

Addressing the gathering, Sir John Russell thanked them for their cordial reception and said that it was a pleasure to him to come to Bangalore, not because he found two of his old students at the Institute, not because he had the pleasure of meeting Sir Raman whose fame as a Scientist was world-wide, not because the Indian Institute was famous all over the scientific world for the value of the work it was doing, but because they were working on problems of fundamental science. In his opinion, an institution which attached full importance to fundamental work could hope to make much progress in its work for the benefit of all concerned.

Sir John Russell observed that Sir Raman might interest himself in Soil Physics. and by so doing he was sure that the same illumination which Sir Raman had shed on other problems in Physics would also be shed on the baffling problem of Soil Physics which was of great importance to agriculture. The problems of Soil Physics and the question of the fundamental relation between colloidal substances in the soil and their power of moisture retention, were of very great importance to Indian agriculture at the present day. Sir John wished to point out to Sir Raman the error of his ways

(laughter) and say how important it was that Sir Raman should, instead of studying the *"Raman effect"* of substances, devote his attention to the study of the Physics of soils in India.

What is Biochemistry?

Continuing Sir John said that Biochemistry was the Chemistry of substances with life. In the early days of Biochemistry, that subject had been a distinct branch of Chemistry, and people had thought of life as entirely distinct from non-living things. That was the origin of the distinction between organic and inorganic Chemistry, a distinction which still survived and caused confusion among students (laughter).

In the second period of the study of Biochemistry it was shown that substances with life could also be synthesised in the laboratories and there was no fundamental difference between organic and inorganic substances. Later still, the difference became one purely of convenience in study. In reality, the realm of Nature was one and indivisible, but they classified their studies into different groups because one man could not study every field, and, also for the convenience of the Universities (laughter).

Agriculture

Agriculture, proceeded Sir John, was defined by a Professor "as something to keep away from". (Renewed laughter). In his young days Sir John had been warned that there was no career to be made out of Agriculture. Sir John, however, held that there was a great deal in Agriculture and that there was a close connection between Agriculture and Biochemistry. As a result of reasoned studies in Biochemistry, they had found it possible to define quality in relation to crops. In England, for example, quality problems in connection with crops were first studied in relation to barley, which was used in the production of beer. Those Indian students who had been in England would know the importance which that liquor played in

English national life (laughter). Later the studies in quality extended to wheat, and it was found that there were three different kinds of wheat—one which was best adapted for loaves, another which was good for biscuits and another which was good for macaroni. What was good for one purpose was not good for the other two. Biochemical study had been able to relate the composition of wheat with the question of its suitability for any purpose.

Indian Ryot

In India they had a very peculiarly important set of problems concerned with the food of the people. Sir John had not got statistical data concerning the daily food of the ryot in India. They had to remember that the Indian ryot was the basic foundation on which the whole of this country was built. In order to arrive at the normal daily food consumed by the average ryot, Sir John had collected figures referring to the total crop production in India and found that the average consumption of grain by the Indian ryot worked out at about one pound per head per day. In the Punjab and in Bengal it was slightly over a pound while it was slightly under a pound in Madras. Curiously enough, Sir John found that that figure tallied exactly with the figure furnished by ryots themselves whom Sir John had interrogated. The normal food of the ryot, in the Punjab, consisted of fifty per cent. wheat, thirty per cent. gram, and the rest cereals. That was a diet very rich in protein. In Bengal, the diet was very poor in protein, as it was almost wholly composed of rice. In Madras they had an intermediate sort of diet, rice accounting for seventy per cent. and the rest being made of protein foods.

Where Biochemistry came into the problem, continued Sir John, was the need for the determination of protein contents in the common grains in use in India. They knew the protein contents of wheat and barley but they wanted more information than was available now about the protein contents of Indian grains. Till that study was completed,

they could not say how the daily diet of the Indian ryot could be improved. The agriculturist could not be expected to know what foods to grow from a dietary point of view.

Sunshine—Source of Vitamins

What was the source of vitamins for the Indian ryots and the agriculturists? In an Indian village, Sir John had met an old man who could not say how old he was but was obviously about 70 years of age. He was still alive but had not eaten an atom of vitamin A, B, C or D (laughter). That was a biochemical mystery which Sir John could not understand. He wondered whether by some physiological process the Indian ryot had evolved the secret of protecting himself even in the absolute absence of vitamins in his food. Scientists, perhaps, in an effort to explain it away, would fall back upon the abundance of brilliant sunshine which they had in India. He felt that there was a great deal in it and that the abundant sunshine somehow or other made it unnecessary for the Indian ryot to have that protection which was afforded by vitamins.

Sir John said that he did not however mean that there was no room for improving the dietary of the Indian ryots. That could and should be improved. In his opinion that problem could be solved only after they had solved the biochemical problems relating to the Indian grains.

Livestock in India

Referring to the conditions of livestock in India, Sir John said that everywhere in India poor stalks of poor crops and very poor grazing fields provided the only food for cattle, that was a terribly inadequate and insufficient diet for the animals. And there was great need therefore for radically improving the dietary of animals both in quality and in quantity. He was however glad to note that at the Animal Husbandry Conference held in Madras they had stressed that point. The bullock was the greatest source of power for agriculturists in India, and they had to remember that power could not be produced out of nothing.

Milk Supply

He deplored that the public did not give sufficient attention to the milk supply which was a most important nourishing food to them. In most villages milk could not be got at all, and in others it could be got only in very small quantities. All those problems to which he had referred were interesting ones, which needed careful study by biochemists in this country.

Cycle in Nature

Sir John then dwelt on the scientific study of soils. He said that they had not yet fully understood the remarkable cycle in Nature with reference to nitrogen production. Though that subject had been fairly fully studied in connection with the temperate climates, yet, in the tropics it still remained to be studied adequately. Particularly with reference to soil study they had to meet large-scale field experiments to ascertain facts and to work out processes. Some work in that direction had been done in the U.S.A. But the results obtained there did not agree with the results obtained in the temperate climates, such as that in England. In England, they had established that the source of nitrogen in the soil was leguminous plants. But in the arid regions of the U.S.A. they failed to get any evidence of fixation by leguminous plants.

Nitrogen Fixation

What they should know, was whether in a country like India fixation by free living organisms played an important part or not as a source of nitrogen. That was a problem of fundamental importance in soil study. In England they could not determine whether nitrogen fixation proceeded independently of leguminous plants. That could be done in a tropical climate. In England, even if they had no rain for ten days they called it a drought (laughter). Even in regard to experiments connected with compost and farm manures, they found that the results varied as between India and the U.S.A. Therefore, if they wanted to obtain

satisfactory solutions for their problems connected with agriculture, biochemists in India would have to solve it for themselves.

Water-logged Fields

The condition of water-logged fields was another direction in which experimental work by biochemists would prove of great value to the Indian ryot. At present, they did not know much about the micro-biological conditions of paddy soils. Sir John felt sure that there was great scope for the application of a great deal of modern knowledge about biochemistry towards the improvement of paddy cultivation. The use of waste products was another direction in which the biochemist could help a great deal. The possibilities of utilising on a commercial scale plants and plant products which were not edible deserved study.

Utilisation of Sewage

The biochemist could also contribute a great deal by studying problems connected with the utilisation of sewage. Sir John was glad to note that Dr. Gilbert Fowler, who had done a great deal of successful work in that direction was present there. In the West, they had succeeded in disposing of the sewage in a healthy manner, though in a wasteful way. They lost the manurial value of sewage. Dr. Fowler's methods, however, enabled the Western method of sewage disposal to be adopted without losing its manurial value. In England they had for a long time been wasting a great amount of nitrogen and phosphates in the shape of sewage, which was allowed to run into the sea. But that was now being remedied and they extracted almost all the nitrogen and a fair amount of phosphates. Phosphates formed an important food material and the supply was almost monopolised by France and the U.S.A. It was even remarked that the civilisation in the West would come to a gradual collapse owing to their shortage of phosphates in Europe. Thanks to the activated sludge method worked out by Dr. Fowler, they were now able to recover a considerable portion of the phosphates from sewage. The only

problem in that connection which remained to be solved was that of drying the truculent colloids.

Sugar Industry

Sir John then made a survey of the rapid growth of the sugar industry in India and the possibility of putting the by-product molasses to much better use than is being done now. He also referred to possible improvements in the production of essential oils. They were, at the Indian Institute of Science, engaged in a field which gave them a great opportunity to add to the richness of life, to alleviate human sufferings and to improve the lot of the millions of agriculturists in this country. He hoped that the triumphs and achievements of Biochemistry would be further improved by the work that they were doing at the Indian Institute of Science (cheers).

With a vote of thanks proposed by Sir Raman the meeting terminated.

"Daily Post," Bangalore.

Agriculture—A Noble Profession

Address to Students on the Hebbal Farm

Sir John Russell visited the Serum Institute and the Experimental Farm at Hebbal on the afternoon of the 16th December 1936. He was shown round the various sections of the Institute and the up-to-date methods adopted in the preparation of the Sera and other biological products. On the Farm he inspected in detail the experimental plots, the types of sugarcane obtained by X-ray treatment and the preparation of compost from farm wastes.

In the evening of the same day he was the guest of honour at the "Tea" arranged by the students of the Mysore Agricultural School, Hebbal. Lady Russell, Lady

Raman and Sir C. V. Raman were among the principal guests of the evening.

Sir John Russell addressing the students after tea, delivered a very instructive speech. He said that agriculture was an important occupation even in such an industrial country as England. In India it was the chief and the basic industry. It was a noble profession as it produced food for the millions. Scientific agriculture was of a recent origin. Improvements were taking place always but they were in the main rather accidental discoveries. Good strains of wheat and even potatoes for example originated from seeds and plants that forced themselves on the attention of certain farmers once in a way. But now-a-days science, specialisation and team-work were brought to bear on almost all the problems and improvements were the results of systematic and predetermined experiments such as are being conducted on the farm itself. Much was already learnt with regard to the various aspects of agriculture but the effect of tillage on tropical soils, in the opinion of Sir John Russell, was still an unexplored field. He felt that there was still so much to be discovered in general and it was so easy to gather new facts in agriculture that even an ordinary farmer going about the fields in the morning with an open eye could return home in the evening with a new discovery.

Sir John Russell told the students that they had chosen a noble profession. India's wealth lay in her soil and the students by rightly adhering to their career would materially add to the wealth of their State.

Dr. V. K. Badami, the Principal of the Agricultural School, thanked the distinguished visitor on behalf of the students and the audience. After the pleasant meeting Sir John and Lady Russell left for the Indian Institute of Science.

(*Adapted from the "Viswakarnataka," a local vernacular daily of the 17th December, 1936.*)

Hebbal Agricultural Farm

Sir J. Russell's Tribute

Sir John Russell, British Agricultural Expert, who arrived in Mysore yesterday, interviewed this morning, observed that he visited the Hebbal Agricultural Farm which is doing very excellent work. "I hope," he said, "that the work carried on at the Farm will bear fruit soon." He added: "Mysore is an interesting State and my regret is that I cannot stop here for a longer period. I carry pleasant memories of Mysore with me."

"The Hindu," Madras.
December 1936.

Indian Peasant Not Averse to Change

Sir John Russell, the agricultural expert, who returned to Madras after a tour in the south, stated in an interview that the average Indian peasant was not altogether the ignorant being he was supposed to be. He had been struck by the qualities of the Indian cultivator, his industry and his steadiness. Sir John added that the Indian cultivator compared very favourably with the peasant in most other countries.

The Indian peasant, though conservative, was not averse to change where he felt it would promote the interest of production and where such a step was within his means. The great problem in Indian agriculture to-day was the poverty of the peasant and there was no use blaming him for what was not his fault, for if he had the money he would take to new and better methods readily enough. The heavy burden of debt on agriculturists was a clog in the wheel of agricultural progress, but that did not directly come within the scope of his inquiry. Sir John, however, recognised its great importance and bearing on agricultural problems in India.

Educated Farmers

In some of the places he had visited in the south, Sir John said, he had met young men who had received education in Colleges conducting farms very successfully. They were able to adjust their agricultural activities to the needs and possibilities of the market, which they had studied and tried to understand. That according to Sir John, was the advantage of education. It would be a very good thing indeed, he said, if educated young men took to agriculture. He hoped that more and more educated youths would settle in the villages and engage themselves in agriculture.

"The Hindu," Madras.
January 1937.

Soil Survey in India—Its Importance

Sir John Russell, the agricultural expert, was present at the joint meeting of the Agriculture and Zoology Sections of the Indian Science Congress.

Rao Bahadur Viswanath, who presided, in opening the discussion emphasised the need for a soil survey in India and examined the scope and nature of such a survey. He emphasised its usefulness in settling the colonisation of new areas and spoke of its assistance to the scientific study of soil.

Sir John Russell said he would not express his final views because he had not as yet completed his work in India. He said a survey was essential in as much as it would give the cultivator an extra acre, if only he knew how to bring into cultivation waste lands.

Sir John paid a tribute to the statistician of the Imperial Council of Agricultural Research, who had summarised a vast number of manurial experiments. The speaker then referred to the need for co-ordination between the engineer and the geologist in irrigation schemes and said that most of the failures in schemes of irrigation were due to an imperfect understanding of the nature of the soil. He

pointed out that engineers should avoid such dangers as water-logging. He commended the work of the Revenue Department in India, which had better documents than in any other country.

"The Hindu," Madras.
January 1937.

Work for Human Benefit can Never be Single-handed

Speaking at the sixth annual meeting of the National Academy of Sciences held at the Vizianagram Hall, Sir John Russell, the British Agricultural Expert, who has done pioneer work at the Rothamsted Farm for about 25 years, emphasised that agricultural life was essential for the well-being of a country. Science had been applied to agriculture in recent years; the inspiration came from the field.

There were two ways of helping the agriculture of a country, one by research work in laboratories and the other by studying practical problems outside. He emphasised that work for human benefit could never be performed single-handed. Organisation and a constant flow of young men with new ideas were a necessity for the purpose.

Agricultural problems, according to Sir John, could be divided into two groups—industrial problems and agricultural research. The agriculturist should first find out what the mill-owner actually required. Research laboratories for such work were also a necessity.

Sir John suggested that Indian students should take to farming and help to increase the output per acre in India. Animal husbandry combined with crop production should go hand-in-hand to improve the situation.

"Daily Post," Bangalore.
January 1937.

Plant Physiology and Chemistry as Basis of Agriculture

Benares Speech

Sir John Russell, the British Agricultural Expert and Director of the Rothamsted Experiment Station, England, who has been specially invited by the Government of India to make a critical survey of the Agricultural Research work going on in the different parts of India, and to give his views as to the future lines of research to be pursued in the country paid a visit to the Institute of Agricultural Research of the Benares Hindu University. He was received there by the Vice-Chancellor Pandit M. M. Malaviya, Dr. B. N. Singh, the Head of the Institute, and other authorities of the University. He was taken round the different laboraratories and the experimental farms of the Institute. Sir John spent about three hours in going through the work carried on there and had a discussion with Dr. Singh and his research scholars on the nature of the work that was being done. It is understood that Sir John was greatly struck by the work started in the field of Agricultural Research at the Institute and expressed his high appreciation of the quality of the fundamental work that was being conducted on scientific lines at the Institute under the guidance of Dr. Singh. The Vice-Chancellor was 'At Home' to meet Sir John and Lady Russell.

Thereafter, Sir John Russell addressed the staff and students at the University. Distinguished ladies and gentlemen including 3,000 students of the University attended the lecture.

Pandit M. M. Malaviya, the Vice-Chancellor, who presided at the lecture introduced Sir John as the leading agricultural expert and scientist of the world and expressed a hope that the report of Sir John Russell after his survey would be a remarkable guide to the future development of Indian agriculture, and that the country would be greatly indebted to him for his strenuous labour and valuable advice

in the field of agriculture which had been the main industry of this country.

Sir John Russell while rising to speak received a great ovation. He said that he had been hearing so much about this great University that he deeply cherished a desire to visit it in person and that evening he was delighted to mention that what he had heard was more than true. He paid a glowing tribute to the wonderful work of Pandit M. M. Malaviya whose single-handed labour, selfless devotion and untiring zeal in the cause of higher education and scientific research had brought into existence within the short space of a few years a great and splendid institution, which any country could be proud of.

Tracing the history of the development of agriculture Sir John Russell said that on going through the literature of Romans, Arabs and Indians it was found that there was much in common not only in the sphere of cultural civilization of the East and West, but also in the field of agriculture as revealed by the fragmentation of land-holdings, use of bullock power, similar yield per acre, etc. This showed that the races inhabiting India and Europe appeared to have a common origin.

Work on plant physiology formed the basis of agriculture in England, Germany and the rest of Europe. One hundred and fifty years ago this science of plant physiology revolutionised their methods and ideas in agriculture and it was a matter of great satisfaction to see that development of agriculture at the Benares Hindu University has been rightly begun by taking up specialised work in the subject of plant physiology. For, unless the life of the plant and its response to the environment was correctly understood no scientific advance was possible in the development of agriculture. The Institute of Agricultural Research of this University was doing valuable work in the field of Plant Physiology, and the more it developed the more it would make a mark in the history of modern agriculture.

Like plant physiology, chemistry was also equally useful as advocated by Leibig and Gilbert (Sir John's predecessor at Rothamsted). On these two fundamental sciences rests the development of modern agriculture. Without the use of plant physiology and chemistry, no advance could be possible in the application of fertilizers and in getting new ideas in the science of agriculture. In agricultural problems no two plants or animals behaved alike and the physiological processes in any two plants or animals always differed. Thus no two experiments with plants gave similar results. This necessitated the development of the science of statistics. Likewise Pasteur's leading researches on micro-organisms had developed the science of Bacteriology which was of very great help in solving practical problems.

Plant pathology, science of plant breeding and plant selection and genetics were some of the other branches of agriculture which had been most helpful.

Proceeding further, Sir John emphasised that pure and applied sciences should be studied side by side with a view to gain the desired object in tackling the problems of practical life. In the West in modern times there had been found considerable synthesis of science and invention. There had been growing a feeling that there was something lacking in the modern civilization and there was the necessity of the synthesis of science and religion and higher philosophy. The paths of science and religion led to the same objective, namely, the finding of the truth. And he was happy to find that this great University was rightly alive to this necessity. While providing for the imparting of instruction in all the branches of arts and sciences, it had not neglected the teaching of religion which was so very essential to true human progress and made thereby possible the compromise in ideals of the East and the West.

"Daily Post," Bangalore.
February 1937.

Sir John Russell, with the Officers of the Department of Agriculture in Mysore.

Dr. N. C. Wright, with the Officers of the Department of Agriculture in Mysore.

Notes and Comments

Sir John Russell and Dr. N. C. Wright Visit Mysore

Nine years ago, the Royal Commission on Agriculture in India proposed the formation of an Imperial Council of Agricultural Research for India to encourage and co-ordinate research work in India. Since the formation of the Council, Provinces and States have joined together to forward the cause of Agricultural Improvement and shown the necessity for joint and co-ordinated action on vital issues. The Council has helped to bring together agricultural research workers throughout India and placed at their disposal the experience of their fellow-workers in this country as well as scientific and technical information from countries overseas. Research and propaganda have expanded in an ever-growing measure. The country has begun to realise that the advancement in commerce and industry is bound up with the prosperity of agriculture. Public opinion is demanding an increase in the pace of agricultural progress and rural development in the widest sense. Administrative measures have been taken to ensure the steady and uninterrupted progress of agricultural improvement in every province of India. In the words of His Excellency Lord Linlithgow, " Agricultural research will merit and will receive public support in proportion as the results of research are translated into field practice, appropriate to the conditions in which the cultivator works and as they are therefore brought home to the villager, the results of research become effective only when, by these processes, they render the business of farming more profitable." During the last few years, much valuable work has been done in India. To judge the value of work done and to suggest new lines of improvement, His Excellency the Viceroy invited two of the Empire's foremost agricultural research workers, Sir John Russell and Dr. N. C. Wright, to inspect and report upon the research work done in India. On the eve of their arrival, His Excellency said, " I am confident that the forthcoming visit to this country of Sir John Russell and Dr. Wright will result in materially advancing the practice

and planning of agricultural research and propaganda and in the improvement of dairying."

The two British Experts and their wives arrived in Bombay from England by the Anchorline steamer *'California'* on Wednesday morning, November 4, 1936. They were met on board the steamer by Dr. W. Burns, the Agricultural Expert to the Imperial Council of Agricultural Research. From Bombay, Sir John and Lady Russell, Dr. and Mrs. Wright went to Delhi. After a short stay there, they have been touring all over the country, and in the course of it, came to Mysore. Sir John Russell was accompanied by Mr. R. L. Sethy, M.Sc., B.Sc. (Edin.), I.A.S., Economic Botanist to the Government of U.P., and Dr. Wright by Captain Aggarwala, B.Sc. (Hons.), M.R.C.V.S., P.V.S., Veterinary Officer, from the Punjab. Both the Experts returned to Delhi to attend the meetings of the Advisory Board of the Imperial Council of Agricultural Research which was held between 25th and 30th of January 1937. They had the opportunity of meeting the members of the Indian Science Congress at Hyderabad in the first week of January 1937. After their tours the Government of India expects from them a report on the work done by the Imperial Council of Agricultural Research.

Sir John Russell, D.Sc., F.R.S., is the Director of Rothamsted Experimental Station in England, the oldest agricultural research institution in the world where experimental work was first started in 1834. He has wide knowledge and experience and agriculture in this country will benefit immensely by his advice. Dr. Wright, Ph.D., who is the Director of the Hannah Dairy Institute, Ayreshire, England, has considerable experience in dairying methods in various countries. He has studied dairy problems extensively in the U.S.A., Scotland, England and Scandinavian countries, where dairying is practised on a large scale.

The visit of these experts to our State cannot be considered to be of mere academical interest. The connection

between the Imperial Council of Agricultural Research and the Indian States has developed into a practical relationship during this decade of intensive research work. The States are represented by their ministers of agriculture and important agricultural officers of their departments on the several committees of the Imperial Council. The State of Mysore has made to the Council a contribution of a lakh of rupees in the first instance and is giving an annual grant of Rs. 5,000. The Council, in turn, is meeting a portion of the finances required for several research schemes started by it in the State. Of such schemes, the enquiry into the cost of cultivation of important crops in the sugarcane and cotton tracts was completed recently. The breeding of thick canes with special references to the effect of X-rays on canes, investigations in connection with local insecticides and researches into the Johne's disease in cattle are in progress. Recently, the Council have sanctioned a grant of Rs. 46,000 towards researches on apples and pineapples on the Fruit Experiment Station to be started near Bangalore. It is also under consideration to start work on the breeding of sheep and rearing of bees. There are researches conducted in co-operation with other organisations also in which the Council is interested, for example, the work on the red-leaf blight of cotton helped by the Central Cotton Committee and that on the quality of coffee helped by the United Planters' Association of South India. Apart from these activities, the Imperial Government itself has its dairying centre in Bangalore, the Imperial Animal Husbandry Institute. The Imperial Dairy Expert is stationed at Bangalore. The work on the feeding value of local fodders and digestibility trials also are being conducted at the Animal Husbandry Institute. It is in the fitness of things that the experts visited the State in December 1936 to take stock of the progress made in all these directions.

Sir John Russell arrived in Bangalore on the 15th of December 1936. On the same day he delivered a speech under the auspices of the Biochemical Association of the Indian Institute of Science on "Biochemistry in Agriculture".

On the morning of the 16th, he visited the Laboratories of the Department of Agriculture. In the afternoon of the same day, he went round the Serum Institute and the Government Experimental Farm, Hebbal. A small exhibition was arranged on the Experimental Farm to bring into view the salient features of the improvements effected in local crops. Sir John Russell inspected these and the various experimental plots, particularly with reference to the sugarcane crop. In the evening, he kindly accepted the invitation of the students of the Hebbal Agricultural School to a 'Tea party'. In his talk to them, he gave sound advice and exhorted them to cultivate a keen sense of observation and told them that their occupation was one of the noblest in life. He left Bangalore on the 17th morning and went to the Irwin Canal Farm, visiting two villages, Oorgahalli and Mayaganahalli on the way. Much of the sugarcane testing work is conducted on the Irwin Canal Farm which is one of the largest sugarcane farms in India. From there Sir John Russell went on to Seringapatam, Krishnarajasagar and Mysore. On the 18th he left Mysore for Ooty, visiting Somanathapur on the way. It was indeed a short stay and while hoping that Sir John Russell will have a pleasant remembrance of Mysore, it may not be out of place to record the impression left by him on our minds. In him we found a keen observer with a broad outlook on life. His advice that research workers should always keep in view the ultimate object of improving the life of the ordinary ryot, will always be remembered by the workers in India.

Dr. Wright was in Bangalore from the 8th to 12th of December 1936 during his first visit, and during his second visit, he returned to Mysore *via* Ooty on the 28th December and toured these parts for a few days. He was in Bangalore again from 31st December 1936 to 2nd January 1937, and left for Hyderabad. He visited the Serum Institute, where research in connection with Johne's disease is being conducted and also the Hebbal Farm for inspection of local live-stock on the 9th December. The Yelachihalli Sheep Farm and the Rayanakere Palace Dairy Farm were visited on the

29th of December 1936. Dr. Wright saw the working of the City Milk Supply Company in both the cities. He visited Chattanahalli to inspect the Palace Amritmahal herd. In Bangalore and Mysore, he visited several private dairy farms. He also visited the Krishnarajapuram Poultry Farm on the 11th of December. Dr. Wright visited the laboratories of the Mysore Agricultural Department on the 2nd January and attended the 'Tea' got up in his honour by the officers of the Agricultural and allied Departments that evening.

Dr. Wright had ample opportunities to study the local conditions thoroughly. We earnestly hope that the Dairy Industry in Mysore will greatly benefit by his advice.

The two great Empire Experts have come and gone leaving behind them pleasant memories. Their visits have given a renewed incentive to research workers. They had ample opportunities to study the progress made in the various branches of agricultural research and their considered verdict and valuable advice will greatly help to push on with the progress of work intended to make the life of the toiling ryot contented and happy.

V. K. B.

SELECTIONS

Cattle Manure: Is It Injurious to Coffee?

Investigations at Donyo Sabouk

Agricultural Department's Comments

Mr. R. A. Clay, of Donyo Sabouk, in a letter which appeared in the *East African Standard* of 1st January, 1937, suggests that "..... cattle manure may be quite useless, or possibly even harmful to the production of high quality good liquoring coffee." Mr. Clay's letter is of such interest that we print it in full in the following columns:—

Is Cattle Manure Harmful to Coffee?

"A neighbour of mine, Major McMaster, has recently made a most interesting graph showing the average London price of Kenya coffee, the average price obtained in London for his own coffee, his annual rainfall, and his annual applications of cattle manure.

The rainfall has had no effect on the comparison of his price with the Kenya price, but the graph shows very clearly that about two years after he started fairly heavy dressings of cattle manure his average price dropped for the first time from well above the Kenya average to below it, and there it has remained ever since.

This is a district of plentiful and cheap manure, and I think I am right in saying that this has been the experience of every estate in the district, though not all, perhaps, have yet realised the reason.

It might, of course, be a coincidence that the whole district, since starting manuring more or less heavily, has dropped to below the Kenya average price from previously always averaging well above it. It might also be due to our trees being older, a possibility which I am trying to test this year by selling the crop separately from the young trees interplanted among my old trees. Anyhow, neither liberal nor light applications of cattle manure have improved our liquor; it is very doubtful if they have improved the size of appearance of the bean, or the proportion of 'A' grade to lower grades; have they increased the yield per acre?

The following average yields per acre of bearing coffee on this estate for three periods of three years each, together with the total

dressings of manure to the whole acreage during these periods, show that they have not.

It should be remembered that it would probably take two years for an application of manure to affect the yield per acre.

We first started to manure in 1927 with a small dressing of 352 tons to a portion of the acreage.

Period A, 1928–30.—Crop averaged 6 cwts. per acre all over (at that time not all the coffee was in full bearing). Manure applied during this period was 14.8 tons at the rate of one to three debbies per tree.

Period B, 1931–33.—Crop averaged 5½ cwts. per acre. Manure applied during this period was 2,555 tons at three debbies per tree.

Period C, 1934–36.—Crop averaged 7 cwts. per acre. Manure applied during this period was 3,521 tons at six debbies per tree.

In spite of all the above it would be foolish to jump to the conclusion that manure is harmful or even useless to coffee, but it certainly does appear that it spoils the liquor, does not improve the size or appearance of the bean, and most surprising of all, does not increase the crop per acre.

No doubt it will be said that had I not applied these dressings of manure my yield per acre instead of keeping fairly steady would have dropped; but this seems to be answered by the fact that I have one shamba which has never been manured at all. The reason for this being that it proved to be such a poor one (bearing for the period 1931-33 an average of under 1½ cwts. per acre) that I thought of abandoning it. However, for the period 1934-36 its average yield per acre rose to 4 cwts. without any manuring at all, and the improvement looks like continuing.

Next year I propose to pick and sell the crop from this entirely unmanured shamba separately, so that a comparison may be made between the quality of its crop (especially liquor) and that of the rest of the estate, all of which has had dressings of six debbies per tree during the last three years, and lighter dressings in previous years.

If any other planters are in a position to make a similar experiment, or have already done so, I, and, I am sure, all coffee planters, would be most interested to hear of any results obtained; and anyhow I would be very interested to hear the views of other planters on this very revolutionary suggestion that cattle manure may be found to be quite useless, or possibly even harmful to the production of high quality good liquoring coffee.

In conclusion, I should state that throughout periods B and C our coffee has always sold at below the Kenya average price. Previously it had always been well above."

Mr. V. A. Beckley, Senior Agricultural Chemist, comments as follows on Mr. Clay's letter:—

"The observations recorded by Mr. Clay are very interesting and illuminating. Although it is impossible accurately to assess quality, the criterion employed here, the comparison between the average price received and the average Kenya price, is better than most. We can accept the conclusion that there has been a loss in quality.

"Some years ago the writer, addressing a meeting of the old Coffee Planters' Union, drew attention to the observations made in Central America, that the use of large quantities of cattle manure or farmyard manure *alone* tended to prolong the period of ripening and thus to reduce the average quality of the crop. This effect is due to the preponderance of nitrogen in such manures. It was further recommended that phosphates should be used in conjunction with farmyard manure and should be added to composts.

"Mr. Clay does not state if he has been using phosphates consistently, but it is to be doubted if he has. The loss of quality observed is very probably due to the heavy unbalanced manuring. As reports have been received from those who have been combining phosphates with bone manure or who have used phosphates in composting to the effect that it appears that prices have improved, it is likely that, if Mr. Clay starts combining bone-meal with his cattle manure, he will observe an improvement in quality.

"Perhaps the writer has been remiss in not more often bringing this aspect of unbalanced manuring before the public. Reference has been made to it a few times only.

"As regards the question of yield there are several factors to be taken into account. The most important are the adverse climatic factors which have been so common during the period under review, especially towards the end. The conditions in a very great part of the coffee areas have been against the trees accumulating food reserves. The result has been that quite a normal crop has constituted overbearing with consequent die-back. The opinion is ventured that Mr. Clay's plantations have suffered very little die-back and have cropped regularly, a condition directly ascribable to the consistent manuring.

"As regards the unmanured plantation there are several factors which may be concerned in the increased yield but without details one cannot discuss them. Mr. Clay would be doing a service to coffee

growers as a whole if he would run an experiment on this unmanured coffee which would give a great deal of information on the questions raised. The experiment I have in mind, in its simplest, consists in dividing the field into six strips, two to be left unmanured, two to be manured with cattle manure at the rate of two debbies per tree, and two strips with cattle manure at the same rate *plus* 1 lb. bone-meal. The crop from each treatment would have to be picked, prepared and sold separately. This is the most difficult part but the results should be of the greatest value.

"In conclusion, I wish to offer my thanks to Mr. Clay for making public his observations and giving opportunity for commenting upon them."

The Coffee Board of Kenya, Monthly Bulletin, Vol. III, No. 25.

Recent Observations Concerning Soil Micro-organisms

A better understanding of the relations of micro-organisms to soil fertility has been sought through three principal lines of investigation: study of the nature of the microscopic inhabitants themselves, the influence of external factors upon their persistence and development, the effects of the products of their diverse activities upon soil conditions and plant development. With the aid of improved methods of investigation, we have learned more about soil organisms and their activities.

Nature of the Soil Population

Through the years, the original concept of the soil population as predominantly bacterial has been modified to include a host of other individuals found among the actinomyces, filamentous fungi, algæ, protozoa, and other tiny animal organisms. By means of observing micro-organisms in the soil directly with the microscope, as provided by the technique of Conn, it has been shown that the small, non-sporulating bacteria predominate and that the larger spore-forming types occur in relatively small numbers except under special conditions. The abundance of bacteria in fertile soils is now calculated in the tens and hundreds of millions per gram, in contrast to a few millions by the plate method. Any attempt to convey definite information about the range in numbers of micro-organisms in various soils is not likely to be satisfactory. Despite numerous quantitative studies the results reported fail to give us a clear picture, largely because of differences in the methods and procedures employed. Despite the limitations of

the various methods, it is apparent that the inherent characteristics of the soil and the practices of soil management exert pronounced effects on the abundance of the microbial population as a whole and upon the relative abundance of the various species.

New revelations of the habits of growth of soil organisms have been disclosed by use of the contact slide method developed by Rossi and Cholodny. This technique indicates the tendency of bacteria to grow in colonies and to develop in local masses in the vicinity of available food materials. The profuse filamentous development of fungi is evident, and sporulation is at times detected. Actinomyces appear as branched filaments, and fragmentation into conidia is readily seen. The digestion of fungous filaments by bacteria and actinomyces is also apparent as one group of organisms succeeds another. The soil microscope of Kubiena is particularly valuable in studying the development of the larger soil micro-organisms about the soil particles and determining the influence of moisture content, aeration, and various other external conditions upon successions of members of the soil population.

Those who have made use of the direct microscopic methods seem almost unanimous in their agreement that, while the methods are of great value in studying the soil organisms, they should not be considered as substitutes for the commonly used plating methods and other procedures, but rather as additional methods to be used to complement the others.

Winogradsky has successfully used enrichment soil cultures and selective silica gel media for studying nitrogen-fixing bacteria, cellulose-decomposing bacteria, and nitrifying bacteria.

Koffman also found direct microscopic study particularly valuable for investigating the soil protozoa. He noted that, unlike conditions in water bodies, tiny flagellates are the most abundant and active protozoa in the soil and that they are not important consumers of soil bacteria. His observations add further weight to the opinion that partial sterilization phenomena are not directly associated with the protozoa in their effects on plant growth.

Various methods have also been devised for estimating the fertility of soils and for detecting deficiencies in soil nutrients. Among these should be mentioned the *Azotobacter* soil plate method developed by Winogradsky, which has proved useful for detecting phosphate deficiencies and the *Cunninghamella* method of Mehlich, Fred, and Truog, developed along similar lines. The growth of *Aspergillus niger* for detecting soil requirements for potassium has been used extensively by Niklas and his associates. Conn has recently made use

of an organism called *Bacterium globiformis* as an indicator of soil conditions. These methods are all based on the use of micro-organisms as test plants, and the assumption is made that the extent and rapidity of their development are determined by the abundance, in available form, of the specific nutrient under consideration. As yet the methods have had rather limited application in practical soil tests, but their adoption may be no accurate criterion of their usefulness.

Pathogenic micro-organisms.—It is now definitely established that many organisms pathogenic to man are of soil origin, that they may survive in the soil for long periods of time and that contaminated soils are able to spread infection. Rhines has recently reported that certain tubercle bacilli survive for many months and may even multiply in this environment. Schalk and his associates found that fowls become infected from litter and soil contaminated with tubercle bacilli as long as 4 years after the original introduction of the organisms. It is indeed fortunate that most animal pathogens diminish in numbers when they are incorporated with the soil. The control of certain animal diseases would be very difficult if the pathogens retained their viability in infected soil. The pathogenic organisms which do persist in the soil are represented by anthrax, black leg, coccidiosis, and others. The persistence and development of organisms pathogenic to higher plants have always been a serious agricultural problem.

Environmental Conditions.

Temperature.—The adjustment of higher plants to temperature ranges within given limits is well known. Potato growers, for instance, go north for their seed in view of the earlier maturing of the crop from northern seed. The characteristic of earliness is an acquired one and may persist for a longer or shorter time.

There is much information in our literature on the general relation of temperature to the growth and activities of micro-organisms, but most of the results are concerned with specific organisms raised in a specific medium. Some observations made by Mishustin are particularly interesting in view of their indication that micro-organisms, developing in their soil habitat, have the capacity of making certain adjustments to climatic conditions. A comparison of optimum and maximum temperatures for soil bacteria shows that there is a ready response to temperature changes. There is a direct relation between mean annual air and soil temperatures, on the one hand, and optimum temperature conditions for growth and development, on the other.

The optimum temperatures for soil bacteria are considerably higher than those which prevail in the soil even in summer. In view of this, it may be assumed that there is utilized by the micro-organisms

only a part—at times, only a small part—of the potential energy resources. As we pass from south to north, the coefficient of such energy utilization tends to decrease.

Mishustin's observations find confirmation in the work of Jenny. As he expresses it: "Within regions of similar moisture conditions the nitrogen and organic matter content of upland, terrace, and first bottom soils, including both prairie and timber vegetation, decreases from north to south". If the data on which Jenny bases his conclusions are correct, we should be justified in concluding that as we proceed from south to north, the available microbiological energy resources in the soil are used to a decreasing extent. There is room for productive work on the temperature-micro-organisms relations in respect to latitude and altitude, with other major factors remaining the same. There are indications that, under the prevailing high temperature conditions of the tropics, microbiological activities may be modified in a very substantial manner. Thus, Dahr and his associates have claimed that in tropical countries temperatures may be too high to permit biological nitrification. Data are offered by these workers and Corbet to justify the assumption that photochemical oxidation predominates in such soils. According to Fraps and Sterges, however, light does not favour the nitrification process in soils under the conditions existing in Texas.

Jensen recently observed that the numbers of bacteria and fungi increase with the moisture content without being appreciably influenced by the temperature. The proportion between bacteria and actinomyces decreased with decrease in moisture.

Salts.—Further confirmation of the conception that the environment may alter, to some extent, the characteristics of the individual members of the population is found in the observations of Baars. Using sulfate-reducing bacteria, he was able to train cultures of a fresh-water form to grow at high salt concentrations. He also accustomed a halophilic form to develop at low salt concentrations. Furthermore, a culture of a thermophilic organism which grew best at 55° C., was so treated that it grew better at 30° C. than at 55° C. It was concluded that the three cultures were the same species, but that the natural environments had altered their ability to tolerate certain temperatures and salt concentrations. In an extensive study of bacteria belonging to various physiological groups, Hof demonstrated that considerable alteration in the tolerance of strains of bacteria to various salt concentrations could be achieved by cultivating the organisms in selective media. He stated, " . . . some common soil bacteria possess the ability to adapt themselves to the

life in salt containing media and in doing so lose the property of development under the conditions of the original environment". "From the results obtained it may be concluded that in fact it is possible to isolate from salt-free material forms which have adapted themselves in such a way to a life in a salt environment that they do not develop subsequently in media without salt. Therefore, it is very probable that many, if not all forms occurring in natural brines are adaptation forms from 'normal' soil bacteria". Soil conditions must continually exert selective influences upon the microscopic inhabitants, favouring the persistence of those strains or varieties which are best suited to development in the particular environment.

Certain heavy metals and other inorganic ions not generally considered to be plant nutrients exert specific effects upon plants or soil substances, some favouring plant development and others having toxic effects. In some soils occurring in regions of deficient rainfall in the United States, selenium occurs in sufficient abundance to be toxic to plants and to render the plants poisonous. It has been found that sulfates reduce the absorption of selenium by the plants. Furthermore, certain fungi appear to be able to decompose insoluble and non-volatile selenium compounds with the release of offensive gases much the same as occurs with arsenicals. Treatment of certain raw peat soils with copper salts has resulted in pronounced improvement in plant development. Zinc sulfate has proved effective in controlling a condition of bronzing of tung trees and chlorosis of corn plants. Similar results have been reported by the California Experiment Station in connection with the treatment of chlorotic citrus trees with zinc sulfate. It is still to be determined whether the influence of zinc and some other metallic ions is a direct one or whether it is exerted indirectly through chemical and microbiological changes produced in the soil.

Moisture.—Extreme desiccation has been long known to kill vegetative cells of many bacteria. McLennan even developed a method for determining the abundance of vegetative fungous growth in soil based upon the destruction of this growth by drying. However, many bacterial cells appear to persist in the absence of appreciable amounts of moisture. Brown found that most bacteria remain viable without being transplanted for many years when rapidly dried on small bits of filter paper and kept under reduced pressure. It has further been noted by Lipman that bacteria are able to persist for long periods of time in dry soils, rocks, coal, mud bricks, and adobe bricks. Such persistence of micro-organisms under extremely adverse conditions insures their wide distribution and their survival in spite of periodic changes in moisture content, temperature, and even reaction.

Reaction.—The influences of soil reaction upon certain soil organisms are also readily detected. It has been noted frequently that the proportion of filamentous fungi to bacteria and actinomyces is greater in acid soils than in those close to neutrality. Many observations have been made that cells of *Azotobacter* are encountered in relatively small numbers in soils more acid than pH 6.0. It also appears that at least certain cellulose-decomposing bacteria are injuriously affected by similar acid conditions. In the absence of the host plant, various species of Rhizobia persist for longer periods in greater numbers in soils which are close to neutrality than in distinctly acid soils. Various fertilizer treatments likewise favour their development. Alway and Nesom found that the soil transfer method of inoculating acid soils for alfalfa was more effective than inoculation with pure cultures. This suggests that some of the characteristics of legume bacteria may be affected by the soil conditions.

These and numerous other studies indicate that the environmental conditions not only affect the relative abundance and distribution of types of micro-organisms, but also may exert some influence upon their physiological behaviours.

Aeration.—It has been clearly demonstrated by plant physiologists that the development and activities of plant roots are greatly affected by the concentration and rate of supply of oxygen in the soil environment. Loehwing states that

> Improper composition of soil air manifests itself in reduced, slow-growing root systems, inadequate absorption, short-lived, discoloured foliage and delay or failure of reproductive processes. The symptomatic complex arising from impaired gas exchange of roots reflects a general reduction in rate and magnitude of normal absorptive and growth processes. The great bulk of existing evidence thus indicates that roots are sensitive to variations in soil air.

As shown by Cannon and Free, roots of plants differ in their requirements for oxygen, but all require at least small amounts. Some species of bog plants and even barley can tolerate as low an amount as 0.5 per cent. of oxygen in the soil gases, at least for a time, whereas others require as great an amount as 10 per cent. The factors of diffusion rates and temperature are closely related to the effects of various gases on root development and plant growth, but no less important is the part played by micro-organisms in altering the ratios of oxygen to carbon dioxide. Although we know, in a general way, the factors affecting oxygen consumption and carbon dioxide production by micro-organisms in soils, there is still much to be learned regarding the influences exerted by micro-organisms upon root development through modifications in the soil gases.

Organic Matter.—Among the various factors affecting soil organisms, certainly the influence of organic materials is one of the most important. Recent reports by Jensen, Brown and Benton, and Gray and McMaster indicate that the principal factor responsible for the variation in abundance of micro-organisms in different soils, and at different depths of the soils, is the nature and amount of the organic matter. Soil reaction is a factor of secondary importance. Studies to explain the reactions involved following the introduction of organic substances into soils, studies of the organisms concerned in the transformations, and the influence of the products upon soil conditions and plant development have commanded some of the best efforts of soil scientists. It is now rather obvious that most of the decomposition is effected by micro-organisms and that many groups of specific forms are concerned in the attack on the numerous compounds contained in plant and animal products. Some of the plant residues are more resistant than others, and it is the more resistant compounds, combined with certain microbial products which characterize the organic matter in soils. According to Waksman, this material, having a relatively high cation-adsorbing capacity, is largely composed of lignin derivatives combined with appreciable amounts of protein materials. It is due to this combination of lignin that the organic nitrogenous substances owe their resistance to decomposition. In such combinations they are but slowly attacked, whereas uncombined, they are quickly decomposed. There are many factors concerning the transformation of lignin in nature that are still obscure and call for an explanation. It seems likely that aerobic conditions are particularly favourable to its destruction and that the accumulation of large deposits of plant wastes has been possible mainly because of the anaerobic conditions under which the materials were originally laid down. The effective utilization of organic matter in soils depends upon the control of the processes of decomposition and accumulation, favouring the mineralization of the nutrients bound up in highly organic soils and leading to the accumulation of greater quantities of organic matter in soils deficient in humus, particularly soils of warm climates.

Interrelations between Higher Plants and Micro-organisms

As higher plants develop in soils, many microbial activities are accelerated and the seat of most intense activity becomes localized, as also happens after additions of organic materials. Extensive development of micro-organisms occurs in the rhizosphere, starting while the plants are still young and continuing throughout the periods of active plant growth. These effects are the result of modifications of the soil environment through physical and chemical changes caused by the

roots. The most pronounced influence is no doubt exerted by organic substances coming from the roots themselves. It is in the rhizosphere that the soil plays its important rôles in the nutrition of higher plants. It is here that the influences of symbiosis, mutualism, stimulation, toxicity, and inhibition become particularly impressed upon the plants. Micro-organisms in the rhizosphere may thus favour the assimilation of nutrients by plants and probably also exert equally injurious effects under certain conditions.

There is evidence of a revival of interest in soil inoculation, based upon the opinion that the organic root excretions are able to support sufficient growth and fixation of nitrogen by *Azotobacter* to satisfy the nitrogen requirements of the plants. Such studies were originally made by Truffaut and Bezssonoff with maize and have been extended by several Russian workers, who conclude that many plants such as tobacco, maize and cotton make appreciably greater growth after inoculation with *Azotobacter*. These results have not been verified by all students of the problem, and there is evidence to indicate that *Azotobacter* does not appear more commonly in the rhizosphere than elsewhere in the soil.

Antibiotic phenomena.—The effects of one organism upon the development of another are, in many instances, so difficult to isolate and demonstrate that comparatively little is known of these relationships which may be of considerable importance in soil processes. Our studies of known cultures have often given a distorted picture of what actually happens in the soil environment. Some highly suggestive results have been obtained, by plant pathologists and others, concerning the relations between certain organisms considered to be soil saprophytes and organisms which invade plant tissues. Sandford studied the possible antagonistic action of soil bacteria to the actinomyces causing potato scab. He suggested that the control through additions of organic matter might be explained, in part at least, through the inhibiting effects of the bacteria which developed upon the green manures. He succeeded, further, in demonstrating that some soil fungi and bacteria suppress the pathogenicity of the wheat root-rot fungus and concluded that antibiotic effects among the soil inhabitants may be very common. Johnson and Bamberg obtained bacterial cultures which were not only able to overgrow the smut fungus of maize, but also inhibited development of the fungus in soil and exerted pronounced control of the infection of the maize plants. Tims isolated a number of actinomyces which inhibited growth of a *Pythium* root parasite of sugarcane and reduced infection through toxic substances which were produced by the actinomyces.

Weindling obtained striking results with *Trichoderma lignorum* which inhibited the development of several parasitic root fungi and prevented root infections in soils. It has been observed more recently by Allen and Haenseler that the *Trichoderma* exerts its influence through materials which are toxic to the parasitic fungi.

Other results of a similar nature have been obtained with many organisms, some parasitic and some saprophytic. Melin observed that certain species of *Torulopsis* depressed development of fungi, causing blue staining of wood pulp, and considered their use for controlling pulp staining in the mills. In forest nurseries, certain organisms are used for a somewhat different purpose. The nursery beds are frequently steamed to kill "damping off" fungi. Seedlings frequently grow poorly in this steamed soil and it has been found that, if the beds are inoculated with some of the prevalent forest nursery soil fungi and bacteria, the seedlings develop better than in either untreated or steamed beds which are not inoculated.

Very often higher plants affected by disease appear to be greatly influenced by soil conditions and the general activity of the microbial population. Cotton root-rot is particularly severe in certain soils of low fertility. Fertilization with suitable quantities of nitrogenous and phosphatic materials and improved cultural practices show promise of greatly reducing the severity of the disease and of providing effective means of control. In this connection, Jordan, Dawson, Skinner, and Hunter conclude, "Evidence is presented to show the importance of the appreciable acceleration of maturity effected by favourable fertilizers in most of the experiments as a means of evading losses of crops due to progressive killing of plants by root-rot." It is further noted that "The direct effect of fertilizers, while of insufficient magnitude to be of economic importance *per se*, is highly significant as reflecting the influence of soil fertility in general and of the use of fertilizers on the effective virulence of the root-rot disease. It also implies that the continued use of appropriate fertilizers in successive years, together with the application of other measures designed to restore or maintain fertility may eventually lead to material control." The treatments were also frequently characterized by enhanced activity of the soil organisms other than the root-rot fungus, and it has been suggested that this may also be concerned with suppression of the disease.

Still another relationship appears between micro-organisms in an extension of the observation that bacteriophage, active against legume bacteria, may occur in the root nodules. Demolon and Dunez consider that the phage lowers yields of alfalfa and causes the decline and failure of alfalfa after a few years. On the other hand, Almon and Wilson failed to note any significant effect of bacteriophage on growth and

nitrogen fixation with red clover, and Laird found bacteriophages of common occurrence in nodules of many legumes. Laird stated, "Thus one may safely conclude that a lytic agent is carried within all nodules in the early stages of growth at least."

There is thus opened a new field of study and, perhaps, of application. Only as the influences of various organisms on one another are understood and the extent of the operation of their effects in soils is known can there be any real appreciation of the associative development of micro-organisms in such a complex environment as the soil. The soil toxin theory of Whitney, Schreiner, *et al.*, has found little support in the results of investigations of recent years, but in its place there have appeared many new explanations of observed differences. Some of these are based upon biological soil factors, and some, on strictly chemical and physical soil characteristics. Experience has shown that soil deficiencies cannot be ascribed to a single factor, but that new problems are continuously arising which find their solution only in hitherto unexpected relationships.

Associations of legumes and non-leguminous plants.—The phenomenon of symbiosis between leguminous plants and their specific bacterial associates has commanded particular attention of agriculturists since the early days of microbiology. The relationships between legumes and non-leguminous plants have assumed new significance in the light of the recent observations of Virtanen and his co-workers. In brief, it is stated that large amounts of organic matter are given off by roots of inoculated legumes and little or none by uninoculated plants. This organic matter is highly nitrogenous, and the nitrogen occurs principally in the amino form. Such nitrogen is available to legumes and non-legumes without undergoing microbial attack, and the nitrogen coming from legumes can supply the requirements of non-legumes growing in association with the legumes. The quantity of organic nitrogen recovered in solution is surprisingly high, frequently being as much as that contained in the entire root system of the legumes and occasionally approximating the amounts in the entire plants. These results would explain the often observed beneficial effects of legumes grown in mixed plantings with non-legumes of both herbaceous and woody types. They deserve more critical study and analysis. In conclusion to a discussion of these relationships, Nicol makes the following pertinent statements:

> Evidence is presented that non-leguminous plants can profitably utilize compounds of nitrogen built up by the symbiotic life of nodule bacteria within their proper leguminous host plants. Some insight into the nature of the transferred compounds has been gained, though the conditions *in vitro* do not admit of facile extension to natural conditions. The mode of transfer from legume to non-legume is still obscure, but the existence of

a transfer can be taken to be well established; it represents a stage in a double symbiosis of which the importance has been fully appreciated. It is probable that in the nitrogenous nutrition of plants some factors are involved which are not yet formulated. These accessory factors may be found to derive ultimately from the animal, aided by activity of legume nodule bacteria in the soil.

Plant stimulants and accessory food substances.—Another suggestive field of research that has recently received new impetus is that concerned with stimulant to plant growth, either arising within the soil through microbial action or produced by the plant itself. Plant stimulants of microbial origin were called "auximones" by Bottomley some 20 years ago. Favourable effects on plant growth from such materials have subsequently been noted by numerous investigators, but there have been differences of opinion concerning the real nature of this phenomenon. It is possible that the microbial substances are not indispensable for development, but that they are concerned with more favourably buffering the nutrient plant medium or rendering greater amounts of iron or manganese available to the plants.

Among the more extreme views which are commanding attention is that of Viswa Nath, Siddappa, Subrahmanyan, and other workers in India who noted that manures and various organic substances affect plant development. It was observed that the seed from plants grown on soils treated with animal manures or other organic materials gave larger yields than seed from plants grown on soils which received mineral fertilizers or no treatment. It was also reported that the seeds produced by plants on manured soils possessed higher nutritive value by reason of their increased vitamin content. These observations led to the conclusion that organic matter functions directly in the nutrition of the plant in a manner analogous to that of vitamins in animal nutrition and that the micro-organisms liberate from the added organic matter some active constituent, which is absorbed by the plant and passed on to the seed. Various results have also been obtained by these workers and by Virtanen and Hausen which show that blossoming of some plants is greatly stimulated following the injection of organic substances or the absorption of such substances by the roots. The effects of such substances appear to be more pronounced in water and sand cultures and it is believed that the stimulating factor is normally present in soils rich in organic matter. In solution and sand-culture experiments in many cases, it is possible to obtain luxuriant development of many higher plants without resort to the addition of organic materials. Growth of plants is greatly affected by differences in the concentration of nutrient salts and by reaction and nature of the nitrogenous material used. It would seem desirable to examine some of these effects more critically.

In connection with growth stimulants, the discovery of a universally occurring stimulant called "pantothenic acid" is significant. Tissues and cells of a great variety of animals, plants, and micro-organisms were found to contain the substance; it has been suggested that it is produced by micro-organisms in the soil and functions widely as a growth catalyst.

Riker and his associates obtained cultures of bacteria which greatly stimulate root development upon plant cuttings. This introduces the possibility of still another specific influence of micro-organisms upon plant development.

Explanations for the effects of some of these substances elaborated by micro-organisms may appear with a clearer understanding of the nature, distribution, and influences of such plant hormones as auxin —*a* and —*b*, hetero-auxin, rhizopin, and rhizocaline, some of which may be produced by micro-organisms. These affect rates of cell growth, root formation, and flower formation of higher plants and also favour the development of some micro-organisms.

Even a superficial examination of the relationships of micro-organisms to soil fertility brings to light a host of interrelated factors, many of which are incompletely understood. The opportunity for discovering unfamiliar phenomena still beckons the observer. The need for accurate evaluation of the relative importance and significance of the various soil activities demands the critical examination and keen discernment of the experienced student. Intelligent control of the direction and rate of the soil reactions in agricultural practice, resulting from the application of facts scientifically authenticated, is a fitting aim for the best endeavours of the soil scientist.

Extracted from *New Jersey Agricultural Experiment Station Bulletin 595, Nov. 1935.*

Broad Relationships between Micro-organisms and Soil Fertility by Jacob G. Lipman and Robert L. Starkey.

Award of the Maynard Ganga Ram Prize

In 1925 the late Sir Ganga Ram, Kt., C.I.E., M.V.O., R.B., Lahore, with that generosity for which he was so well known, handed over to the Punjab Government a sum of Rs. 25,000 for the endowment of a prize of the value of Rs. 3,000 to be called the Maynard Ganga Ram Prize and to be awarded every three years, for a discovery, or an invention, or a new practical method which will tend to increase

agricultural production in the Punjab on a paying basis. The competition is open to all throughout the world. Government servants are also eligible to compete for it.

The first award which was due in 1929 was made in 1931 to Dr. Barber, late Imperial Sugar Expert, for his fundamental discoveries which resulted in the production of Coimbatore Sugarcane. During the last five years no further awards have been made owing to lack of suitable entries concerning which sufficient information was available. The 1932 award has now been made by the Managing Body to Mr. T. A. Miller Brownlie, late Agricultural Engineer to Government, Punjab, for his invention of a slip strainer suitable for water augmentation supplies derived from bores sunk in open wells. This strainer has the particular merit that it is not affected by alkaline sub-soil water—a defect from which many of the earlier metal strainers suffer. The new strainer is also cheaper than the former types in use. It has been tested now for several years in a large number of wells and has given excellent results. By its use owners of well-irrigated lands can increase the output of water from their wells. Consequently they can grow a larger area of crops on wells so equipped and a greater range of better paying crops.

Meantime the 1935 award fell due. The Managing Body has awarded it to R. S. L. Jai Chand Luthra, I.A.S., Professor of Botany, Punjab Agricultural College, Lyallpur, for his new method of treating wheat seed in order to free it from a fungal disease called Loose Smut. This disease is present in most parts of the province and causes considerable loss to cultivators. The old method of treatment involved the use of a thermometer and required skill and accuracy in raising water to a temperature which was sufficient to kill the spores of the disease inside the wheat grain and yet not damage the germinating power of the grain. Consequently, the method was unsafe in the hands of unskilled and illiterate people. By R. S. L. Jai Chand Luthra's method the use of a thermometer is rendered unnecessary. The wheat seed to be treated is merely soaked in water at ordinary temperature for four hours during the morning of a day in summer. Thereafter the soaked grain is spread in the sunshine till it is thoroughly dried. Experience has shown that this treatment is effective in controlling the disease without damaging the germinating power of the seed. It can be carried out safely by any illiterate worker.

Entries for the next award should reach the Director of Agriculture, Punjab, Lahore, on or before the 31st December, 1938.

Communicated by the Director of Agriculture, the Punjab.

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